Remarks

The amendment to claim 1

Examiner will immediately see that claim 1 as amended is fully supported in the Specification as filed. FIG. 18 shows the linear projections of the ray at 1821 and 1827. The section of the Specification beginning at page 53, line 1 discusses how data may be associated with voxels and how the data associated with a voxel may affect a ray.

The rejection under 35 U.S.C. 101

Applicant has amended claim 1 so that it now clearly points out that "certain of the voxels [are] associated with data that affects rays" and that "the data associated with the intersected voxels [is examined] to determine how the ray is affected thereby". As now claimed, the method of claim 1 is used to determine how data associated with the voxels intercepted by a ray affects the ray. As is apparent from the discussion beginning at page 53, line 1 of Applicants' Specification, the claimed method is "useful" and produces "concrete and tangible results", namely the rays as affected by the data associated with the voxels that are intersected by the ray. As amended, claim 1 thus does not set forth a judicial exception to statutory subject matter according to the criteria set forth in the Interim Guidelines and is consequently directed to statutory subject matter. The language used in amended claim 1 comes from independent claim 12 as originally filed, and so that claim, too, passes muster under the criteria set forth in the Interim Guidelines. Since the two independent claims in the application are directed to statutory subject matter, so are all of the dependent claims.

Traversal of the rejection of claims 1, 2, 10, and 11 as anticipated by Schröder

A rejection under 35 U.S.C. 102 requires that the reference upon which the rejection is based show all of the limitations of the claim that is under rejection. In the following, Applicant will first set forth what is being claimed and will then show that Schröder does not disclose all of the limitations of the claims.

What Applicant is claiming

The rejected claims other than claim 1 are all dependent from claim 1 as now amended, which may therefore be taken as exemplary for what Applicant is claiming. Applicant has added reference numbers to aid Examiner in interpreting the claim but is not thereby limiting the claim:

1. (currently amended) A method practiced in a computer system of determining voxels (1911, 1913, 1915) in an object space (1801) that are intersected by a ray (1816), certain of the voxels being associated with data that affects rays and the method comprising the steps of:

making linear projections (1821, 1827)) of the ray on a plurality of planes (1833,1835) in the object space;

determining cells (1929, 1931, 1923, 1925) in the planes that are intersected by the linear projections; ~~and~~

using the intersected cells to determine the intersected voxels; and

examining the data associated with the intersected voxels to determine how the ray is affected thereby.

As may be seen from the claim, the method determines which voxels in an object space are intersected by a ray. The technique the method uses to do this is to project the voxel on a plurality of planes in the object space, then to determine cells on the planes that are intersected by the projections, and then to use the intersected cells to determine the intersected voxels. Once the intersections are determined, the data associated with the intersected

What Schröder discloses

As is apparent from the *Abstract*, Schröder discloses a technique for determining the values of pixels in a planar image of a volume of space. The plane may be at an angle $\theta \in \left[-\frac{\pi}{4}, \frac{\pi}{4}\right]$ to the major axis of the volume. The value of each pixel in the planar image is determined by tracing a ray corresponding to the pixel through the voxels of the volume and computing the path integral of the ray. As set forth at section 1.2 of the reference, Schröder's technique is a ray tracing technique that uses an object space method to resample the volume at sample points along the rays. The difference between Schröder's technique and other such techniques is described as follows:

> In object space methods the volume is left in its local coordinate frame and instead rays are subjected to the inverse viewing transform. Each ray parameterizes a set of sample points along its length, some of which will lie inside the volume. In order to resample using tri-linear interpolation the eight grid points surrounding a given ray-sample need to be accessed. Since the mapping of samples onto voxels is not one-to-one-some voxels contain more than one ray-sample, others none--a SIMD implementation appears to require general communication. The present algorithm addresses this concern by describing a mapping of ray-samples onto the volume which is one-to-one. This mapping uses the idiom of line drawing on discrete grids [3]. Instead of transforming the volume once for a given rotation, we step the rays through the volume for each rendering.

Schröder's FIG. 1 shows the basic technique as it is applied to the rays corresponding to the pixels which make up a single line of pixels in the image plane. A version of the figure to which reference numbers have been added to clarify the discussion is attached to this response. The line is shown at 301(i) in the figure. A ray 303 is defined for each pixel on line 301(i). The ray 303 is perpendicular to line 301. The rays 303 define a plane which passes through volume 304. The axes of the plane are shown at 302. The plane defines a slice 305(i) of volume 304. The slice is defined such that the plane bisects the slice. The voxels 307 in the slice are defined such that each ray in the plane passes through the midpoint of the face of the voxel at which the rays enters the slice. As shown in FIG. 1, this definition of the slice and of the voxels in the slice ensures that only a single ray 303 passes through each voxel in the slice. In FIG. 1, which is in two dimensions, the slice of voxels 305(i) appears as a plane. The value of each pixel on line 301(i) is determined from the path integral of the voxels 307 in slice 305(i) through which the ray corresponding to the pixel passes. A similar slice 305(i) through volume 304 is made for each line 301(0..n) in the image plane and the rays corresponding to the line's pixels are processed as just described. Since the path integrals for the rays 303 corresponding to the pixels of each line 301(i) can be computed in parallel and the slices can be processed in parallel as well, the method is well adapted to parallel processing.

FIG. 1 shows the simplest case, where all of the rays being considered pass through the front and rear edges of the slice. FIGs. 2 and 3 show how the technique deals with rays for which that is not the case. Space is tiled with copies of the volume until all of the rays enter at the front edge of a slice of the original or a copy and leave at the rear edge of the slice, and thus all rays can be treated as described for the simplest case. This technique of course depends on the fact that rays 303 are parallel to each other and that the voxels in the slices are defined such that the rays pass through the centers of the voxels on the front edge of the slice.

Why Schröder does not disclose all of the limitations of Applicants' claim 1

In Schröder, a slice 305(i) and the voxels in the slice are set up such that each ray is on a plane which bisects the slice and that each voxel is intersected by only a single ray. Because that is the case, there is no need whatever in Schröder to "mak[e] projections of the ray on a plurality of planes in the object space", to "determin[e] cells in the planes that are intersected by the projections", or to

"us[e] the intersected cells to determine the intersected voxels", as set forth in Applicants' claim 1 and there is in fact no such disclosure of these limitations in Schröder.

Examiner cites the Abstract and FIG. 3 for such disclosure, but the Abstract merely sets forth that

> The algorithm uses the idiom of line drawing to traverse the data set when evaluating the path integrals corresponding to a ray tracing of the volume. Since the rays of a parallel projection correspond to a single line instanced multiple times across the viewing plane the approach lends itself well to implementation on massively parallel computers.

Line 301(i) of FIG. 1 is of course not a *projection* of a ray. As for FIG. 3, the figure shows a ray passing through a volume. There are no *projections of the ray* shown in that figure and the discussion of the figure at col. 2, lines 27-30 make it clear that the purpose of the figure is to show that a ray that passes through a volume can have at most three segments, and consequently, no more than three copies of a slice are needed for the ray.

Because Schröder does not employ ray projections as set forth in claim 1, the reference cannot anticipate claim 1. Claims 2, 10, and 11 are dependent from claim 1 and of course cannot be anticipated if claim 1 is not anticipated. Further, these dependent claims set forth details of the projection technique, and since Schröder discloses nothing about projecting rays onto planes in the object space, the dependent claims are also patentable over the reference in their own rights.

The rejections of claims 3, 6, and 7-9, under 35 U.S.C. 103

In order for a rejection under 35 U.S.C. 103 to be made, the combination of references used to make the rejection must show all of the limitations of the rejected claim. In the case of claims 3, 6, and 7-9, Schröder does not disclose all of the limitations of claim 1 and consequently, the combination of Schröder with the other references cannot disclose all of the limitations of claims 3, 6, and 7-9 and the rejection of these claims under 35 U.S.C. 103 is without foundation. With regard to claims 7-9, it should be pointed out that neither Schröder nor Kaufman discloses anything at all about using cells intersected by the projections of the ray to determine the voxels intersected by the ray, and consequently the references provide no motivation for determining from the intersected cells whether the voxels are edge connected or corner connected. Claims 7-9 are thus patentable in their own rights over the references.

The rejection of claim 12 under 35 U.S.C. as obvious over the combination of Lacroute and Schröder

Claim 12 reads as follows:

> **12. (original)** A method practiced in a computer system of traversing a volume with a particular ray of a plurality thereof, the volume being subdivided into first runs of voxels, certain of the voxels being associated with data that affects rays, and a ray intersecting one or more of the first runs and being defined as a set of second runs of voxels, and
> the method comprising the steps of:
> for a second run belonging to the particular ray, determining whether the second run includes a voxel of a first run that affects rays; and
> when the second run includes such a voxel, examining the associated data.

The technique set forth in the claim is described beginning at paragraph 0449 of U.S Patent Application Publication 2005/0116951, which is the published application for the present patent application. The volume being traversed by a ray is first subdivided into "first runs of voxels" that are embodied in the encoding runs 2603 of the discussion beginning at paragraph 0449. The encoding runs use run-length encoding to decrease the amount of data in the run. The ray is then defined as a set of second runs of voxels that are traversed by the ray. These are the runs of voxels shown at 1911, 1913, and 1915 in FIG. 19 and also in FIGs. 21, 22, and 24. The method finds out how the contents of the voxels in the volume affect the ray by determining whether there is an intersection between a run of ray voxels and an encoding run. if there is, and the encoding run indicates that the voxel of the encoding run at the intersection is associated with data that affects the ray, the data indicated by the encoding run is examined.

In his rejection, Examiner finds that Schröder discloses the second run of voxels and Lacroute discloses the first run of voxels (the encoding run). Lacroute does in fact disclose a data compression technique which is related to the one used in Applicant's first runs in section 3.1 and FIGs 4 and 5. However, the technique is used in a completely different context. In Lacroute, the problem of tracing rays defined by an image plane through an object space is simplified by first dividing the volume space into slices of voxels, then shearing the slices so that the voxels form columns that are perpendicular to the slices and then warping the rays so that all of the rays are perpendicular to the slices and each ray passes through all of the voxels in a single column of voxels. All this is shown in FIGs. 1 and 2. To speed up computations with regard to the ray that

passes through a column, Lacroute uses run length encoding in the column. The encoding is shown in Fig. 4.

The problem with Examiner's rejection is simply this: both Schröder and Lacroute disclose runs of voxels through which rays pass. These runs of voxels can be taken to correspond to Applicant's second runs of voxels. Lacroute further discloses run length encoding employed in his runs of voxels. The combination of references does not disclose what Applicant is claiming in claim 12, namely a first run of voxels in which the voxels are associated with data that affects rays, and a second run of voxels that defines a ray and the second run of voxels that defines the ray intersecting one or more of the first runs. Because the runs of voxels in Lacroute in which the run length encoding is used are also the runs of voxels which belongs to the rays, there can be no first runs of voxels that are intersected by second runs of voxels, and consequently the combination of Schröder and Lacroute does not disclose all of the limitations of claim 12. Since that is so, the rejection under 35 U.S.C. 103 is without foundation. Because claim 12 is patentable, so are all of the claims dependent from claim 12.

Conclusion

Applicant has been completely responsive to Examiner's rejections in his Office action of 3/28/06 and has thus satisfied the requirements of 37 C.F.R. 1.116(b). Applicant consequently respectfully requests that Examiner enter the amendment, continue with his examination, and allow the claims as amended, as provided for in 37 C.F.R. 1.116(a). A petition for a one month extension of time accompanies this response. Please charge the $60.00 fee for the petition as well as any other fees required by way of this amendment to deposit account number 501315.

Respectfully submitted,

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